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MICHIGAN

AGRICULTURAL EXPERIMENT STATION.

STATE AGRICULTURAL COLLEGE.

FARM DEPARTMENT.

SMUT IN OATS AND WHEAT

Jensen or Hot Water Treatment.

Third Edition, with Additions.

BY P. M. HARWOOD AND
P. G. HOLDEN.

The Bulletins of this Station will be sent free to all newspapers in the State, and to such individuals interested in farming as may request it. Address all applications to the Secretary, Agricultural College, Michigan.

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SMUT OF OATS AND WHEAT.

At a Very Low Estimate the Smut Crop of Michigan has Cost the Farmers more than $1,000,000 this Year.

THE HOT WATER TREATMENT FOR SMUT OF OATS AND WHEAT.

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Owing to the interest which farmers have manifested in this subject, and the unusual demand for Bulletin No. 87, we have decided to publish a third edition, with improved methods of treatment which we have found by a large number of experiments to be advantageous.

Numerous letters have been received from various parts of the state, calling attention to the great damage done by the smut of oats and wheat (especially the former) and asking for remedies. The loss to Michigan farmers in the oat crop last year, by smut, was probably not less than $800,000, and this year it exceeds that amount by at least $200,000. In all the communications which I have received this year from different parts of the State, where actual counts have been made the percentage of smut, in no case, has been less than 8 per cent, and in many cases it reached as high as 20 per cent, averaging about 15 per cent.

The extent of loss by smut is seldom appreciated until an actual count is made. The smutted stalks are shorter than the others and before the oats are ripe the smut is blown away, leaving the bare stalk, which will not be readily noticed.

In every case where the farmer has estimated from three to five per cent of smut in his oats, actual count has shown from 10 to 15 per cent. The following from U. S. Farmers' Bulletin No. 5 on the "Smuts of Oats and Wheat," by W. T. Swingle, who has given the question a great deal of attention, will show the importance of treating oats for smut.

"Whenever careful investigations have been made the per cent of heads attacked by smut has been found to be considerable. The average loss is from 5 to 12 per cent in different localities in the United States. The percentage of smutted heads also varies in a given locality in different years. Usually the smut is not noticed at all unless it is very abundant, for by harvest time most of the smut has fallen from the diseased heads leaving only the bare and inconspicuous stalks. The question will no doubt be asked: Will it pay to treat the oats for seed when only five or even ten per cent of the heads are smutted?

"It may be said in answer that the per cent of heads destroyed by smut does not represent the amount that will be recovered by treating the seed. In all the careful experiments made with the methods of seed treatment as described below there has been found to be an *extra increase* beyond and above the amount that would naturally be expected by replacing smutted heads with sound ones. This extra increase is found to range from one to ten times the amount of direct damage resulting from the loss of the smutted heads. Besides this gain there is that arising from the fact that the oats raised from treated seed *will produce a crop free from smut*, if there are no smutty oats in neighboring fields.

"Taking all these facts into consideration it is highly probable that it will be found profitable to treat seed oats if they come from a field showing more than one per cent of smutted heads, and it will certainly pay to treat the seed if it come from a field showing more than three per cent of smutted heads. It is a fair estimate based on counts made in many parts of the Union to estimate the *net gain* to be obtained by treating seed oats at 8 per cent of the crop obtained. Since the aggregate value of the oat crop of the United States from 1880 to 1890 was $2,030,712,605, the net gain from a universal system of seed treatment would have been $162,457,008.40 for those years.

"Every farmer who raises oats is strongly urged to treat the seed unless, upon careful counts made in different parts of the field, there are found to be less than three heads smutted in every hundred. Above all *do not conclude that* because you have *not noticed* any considerable amount of smut in your fields it will not pay to treat the seed. The safer method is to treat the seed unless the field from which it was obtained is known to be *free* from smut. It should also be remembered that the gain is just as real even if the oats are not a paying crop, or if merely grown for straw, for there is found to be an increase in the weight of straw grown from treated oats."

*THE LOOSE SMUT OF OATS.

"In case of loose smut of oats the grains and usually the husks are transformed into a black powdery mass consisting of the spores of the

*See Farmers' Bulletin No. 5, by W. T. Swingle.

fungus intermixed with shreds of tissue of the plant itself. The oat plants first show signs of the disease at the times of heading out, when, instead of a normal head, a smutted one is produced.

"The smut becomes fully mature at the time of blossoming of oats and is then easily scattered by the winds. By harvest time the smut has often been entirely blown away, leaving only the naked stalk remaining.

"The fungus is known to botanists as *Ustilago avenæ* (Pers) Jensen.

"Plate I, Fig. 1, shows a large smutted head, the husks of which are only partially distroyed by smut; Fig. 2, a fully smutted head; and Fig. 3, a fully smutted head as it appears at harvest time with nearly all the smut blown away."

*THE STINKING SMUT OF WHEAT.

"This smut unlike that of oats affects only the grain. In consequence the heads have nearly their normal appearance. Upon close examination the grains are seen to be swollen, of a greenish color at first, but finally brown or gray. If one of these swollen, smutted grains be crushed it will be found to be filled with a dull brownish powder which has a very penetrating and disagreeable odor. The presence of this odor, which has given rise to the common name, is a very good test for the presence of the smut. The smut is due to either of two very nearly identical fungi, *Tilletia foetens* (B and C) Schrœt and *Tilletia tritici* (Bj) Wint. The same rteatment will destroy both.

The former of these smuts, *Tilletia foetens*, is what is known by the farmers of the southwestern part of Michigan as "high smut," while the second, *Tilletia Tritici*, is known as "low smut." To Mr. Enos Holmes, of Buchanan, Mich., is due the credit of first calling our attention to the fact that there is a "low" and a "high" smut. So far as I know botanists have failed to distinguish the difference between the heights of growth of these two smuts. The wheat affected with low smut grows from 1 to 1½ feet in height, while the "high" smut is but little, if any, lower than the unaffected wheat.

Figs. 4 and 5 of the plate show smutted heads of bearded and beardless wheat respectively.

LOW SMUT.

Mr. Enos Holmes, who has sent us a large number of specimens of both "low" and "high" smut selected from different portions of the field, writes as follows about "low" smut: "The 'low' smut does not seem to do as much damage as the 'high' smut. Usually but a small amount of wheat is affected by it while I have known and have myself had whole fields that were one-half to three-fourths smutted with high smut.

Threshers tell me that "low" smut is not as heavy as "high" smut and is nearly all blown out in threshing. It is the generally received opinion here that there are two distinct species. I find much smut that is almost as high as the "high" smut. Low smut is usually found in such portions of the field as have been much trampled by stock, near some gate for instance, or at the corners of a land in plowing, where the horses tramp in turning. Some of these specimens were obtained near a neighbor's

*See Farmers' Bulletin No. 5, W. T. Swingle.

yard, where his chickens worked some, and to that cause he ascribes the fact of its being smutted, though I think it is wrong, for the smut extends three or four rods along his fence and beyond the work of the chickens. This smut will average about twelve inches in height, and does very little harm except in so far as the smutted heads replace sound ones, for the reason that in cutting, the smut heads are left uncut, or are so near the butt of the bundle that they rattle out. I also notice that, while many plants affected by the smut have no sound heads, very many stools will produce both sound wheat and smutted heads like those I send you.

The "high" smut, so called, on the contrary rarely produces sound heads on a smutted stool in this region. I have never found any myself, though I do not doubt their existence, having seen smut kernels and sound ones in the same head, also kernels which were part sound and part smut. Another point of difference is that "high" smut grows indiscriminately through the field while the low smut is usually confined to such places as have been before mentioned.

Corn smut, the loose smut of wheat, that which destroys the whole head, are caused by different species of smuts, and as yet we have no remedy for them.

METHOD OF INFECTION OF WHEAT AND OATS.

The spores (seed of the smut) attach themselves to the kernels of wheat or oats and are sown with them. When the kernel of wheat or oats germinates the smut spores also germinate and enter the young plant, growing and subsisting on the inside of the plant until finally, when the head appears, it is smut instead of wheat or oats. It has cost nearly or quite as much to grow the affected plant as a healthy one. We ask for bread and receive smut. Certain conditions of soil or weather may be more favorable to the growth of smut than others, but let it be distinctly understood that its presence is not due to any condition of soil or weather. We sow smut and we reap smut. In the case of oats the wind may carry the loose powdery smut over the fields and the spores become attached to the kernels of oats. These spores are so small that they can not be seen with the naked eye unless there are many together, but they are there ready to grow when the oats are sown. But probably the threshing machine is the most effective way of bringing the spores of smut into contact with the wheat and oat seed. A single kernel may have thousands of these spores attached to it yet not be observed. The threshing machine becomes a ready means of carrying the smut from one farm to another. It has been found that these adhering spores may be killed by dipping the seed into hot water for a few minutes, and yet not injure the vitality of the seed. This method, known as the Jensen, or hot water method, was discovered by J. L. Jensen, of Denmark, in 1887.

METHOD OF TREATMENT FOR WHEAT AND OATS.

The farmer may use his ingenuity in regard to the treating of his wheat and oats, and use whatever conveniences he has at hand—anyway so that he accomplishes the desired result.

One way we find convenient is to have a kettle in which to heat the water quite hot, say 165°.

Near this kettle place a barrel in which to treat the seed. Fill this barrel about one half full of hot water from the kettle and then by adding either hot or cold water, the temperature of the water in the barrel may be kept at the desired height.

It will be found very convenient to have the barrel in which the seed is to be treated sunk into the ground so that the top is only a foot or so above the surface.

Into this barrel dip the seed.

The dipping is easily done by placing about a bushel of seed into a coarse gunny sack, and fasten this sack to one end of a long pole used as a lever hung across a notched post.

The seed should be kept moving all the time while in the hot water and by using the pole this is easily done.

Oats may be treated just before sowing.

After taking them out of the barrel of hot water it is best to throw cold water over them to cool them off, and then let them stand and drain two or three hours after which they may be sown broadcast.

Wheat dries much more readily, so if spread out immediately after treating and left to dry a few hours, it can then be sown broadcast or in a force feed drill.

As the grains will be considerably swollen after their treatment it is well to regulate the drill to feed from one to two pecks more per acre than with dry seed.

It will be readily seen that this method is in the reach of every farmer. All that is required is one kettle, one or two barrels, and a coarse sack.

Two men in one day can treat enough oats to sow 20 acres or enough wheat to sow 40 acres.

One caution to be observed is that of using no bags or dishes for treated seed that have been used for the untreated seed, unless they have first been scalded.

The water should be at 135° when the wheat or oats are put in. Allow the grain to remain in the water five minutes and keep the temperature above 130°. Keep the seed moving all the time it is in the barrel by means of the pole to insure thorough treatment of all the seed.

Aim to keep the temperature as nearly 134° as possible. When the seed is first put in the temperature of the water will fall rapidly but by adding hot water it can be raised quickly to 134°.

We take the liberty of publishing the following letters from two of our farmers who have used the hot mater treatment:

HOLLY, Mich., Oct. 28, 1892.

MR. HOLDEN:

SIR—The water was heated to a temperature of 135°. The oats were placed in coarse, gunny sacks, and were kept in the water at that temperature five minutes, then taken out and partially dried. A strip of about an acre subjected to the hot water treatment was sown through the center of the field on the same day and of the same seed as the untreated oats. On the strip thus treated no smut appeared. The remainder of the field was, on a conservative estimate, one-tenth smut.

LEWIS MARSH.

UNION CITY, Oct. 8, 1892.

MR. HOLDEN:

SIR—I made a basket of an old screen door that would hold about one bushel. I found this to be much better than a cloth bag as the water came in and went out much quicker and allowed me to stir the oats readily while treating. I had two kettles, one to heat the water in, from which the water was dipped into the other where the oats were, so as to keep the one where the oats were being treated nearly up to 130°. Sometimes the water was as high as 140° when the oats were put in. The aim was to keep the water as near 130° as possible. The oats to be left in five minutes. Did not dip them in cold water, but spread them immediately. We had some trouble in drying them as we spread them too thick on the granary floor. Sowed twenty acres, part with drill and part broadcast. The seed for about sixteen acres was treated. *I think that if the oats had been spread thinner while hot on a large floor they would have dried very soon.

I counted the smut in a drill mark of the untreated oats and found one head in from four to five smutted, while I found none in those treated. The oats from the treated seed looked better than those untreated. Two strips through the field were sown with untreated seed. I shall try treating oats next spring as I am thoroughly satisfied that it pays. A temperature of 130° for five minutes was entirely satisfactory. The seed treated was very smutty. I should judge that two men would treat about one bushel in ten minutes.

Yours truly,
J. R. BLAKE.

FOR OATS.

The hundreds of experiments conducted at Kansas, Indiana and other experiment stations with treated and untreated seed sown side by side have shown the practical value of this method.

Prof. Swingle and Prof. Arthur tell me that the farmers who have tried it in Kansas and Indiana are enthusiastic in its favor. Had all the farmers of Michigan treated their seed last Spring, there would have been saved to the State more than a million of dollars. The farmers who raised 20 acres of oats with straw, promising 50 bushels per acre, received but 45. In other words the farmer loses 100 bushels of oats. This is a low estimate for in no case where farmers actually counted the smutted stalks did the per cent fall below 8 and in many cases it reached 20.

The loss on the College farm this year will not be less than 350 bushels. The cost of treating is very slight compared with the damage done by the smut.

The farmer who treats his seed will save several times the cost of treatment the first year. If there is no smut in the adjoining fields of oats, and his treatment the first year killed the smut, he will not need to treat his seed the second year and perhaps the third year. But if his neighbors do not treat their seed, his oats will soon become affected by the threshing machine and perhaps in other ways. In Kansas, so I am told

* We have made a thorough test at the college on the drying of oats and do not recommend it. It is almost impossible to dry them as the hulls hold the water. We advise sowing broadcast under the circumstances. Wheat will dry in a few hours so that it can be sown with drill.

by Prof. Swingle, one farmer of a neighborhood will treat his seed and the next year his neighbors depend on him for their seed to sow.

It has been found by Jensen of Denmark, Kellerman and Swingle of Kansas, J. C. Arthur of Indiana, and others "that the per cent of heads destroyed by smut does not represent the amount that will be recovered by treating the seed." There is an *extra increase* beyond and above the amount that would naturally be expected by replacing smutted heads with sound ones." This extra increase in yield is due in some way to the effect of the hot water on the seed, unless perhaps the smut may have a more injurious effect on the yield than is represented by the per cent of smutted oats that can be seen. These experiments have been too extensively and accurately carried on by different scientists to admit of any doubt as to the "extra increase" beyond simply destroying the visible smut."

*Jensen found an increase of 5%, J. C. Arthur 7%, and Kellerman and Swingle a much larger increase. The farmer will find more time to treat his seed in the winter but in this case care must be taken to dry it thoroughly. We advise treating only a few hours before sowing as it will be found very difficult to dry sufficiently to store. If treated a day or so before sowing the seed should be well spread to dry.

Two factors must be born in mind, the water must be hot enough to kill the smut spores attached to the kernels but not so hot as to kill the seed. It has been determined by a large number of experiments that 129° is the lowest temperature which will destroy all the smut. The following tables will show the upper limit of safety. The first and second tables are the results of extensive experiments made by Prof. J. C. Arthur of Purdue university, and published in Agricultural Science for September, 1892. The 3d table gives the results of the experiments at our own station.

I. *Germination of wheat treated with hot water.*

Temperature of water.	Time of immersion.	Per cent germin't'd in 24 hours.	Total per cent germinated.
Untreated		9.8	94
130°	5 minutes	14.5	90
135°	"	12.4	91
140°	"	6.7	73
145°	"	1.	62
150°	"	0.	33

II. *Germination of oats.*

Temperature of water.	Time of immersion.	Per cent germin't'd in 24 hours.	Total per cent germinated.
Untreated		7.3	95
130°	5 minutes.	23.4	93
135°	"	17.3	93
140°	"	6.3	94
145°	"	6.5	89
150°	"	5.9	89
	3 minutes.		

III. *Germination of wheat treated with hot water.*

Temperature of water.	Time of immersion.	Per cent germin't'd in 47 hours.	Per cent germn't'd in 75 hours.	Total per cent germinated.
Untreated		100	100	100
125°	5 minutes.	100	100	100
128°	"	100	100	100
131°	"	100	100	100
132°	"	100	100	100
133°	"	100	100	100
134°	"	100	100	100
135°	"	100	100	100
136°	"	90	100	100
137°	"	100	100	100
138°	"	85	85	90
139°	"	90	90	100
140°	"	75	90	95
141°	"	35	55	65
142°	"	40	50	70
143°	"	20	40	70
144°	"	25	30	55
145°	"	5	35	55
150°	"	0	5	40

It will be noticed that the upper limit of absolute safety for wheat is about 136°. Above 137° the germination was slow and the young plants weak, which showed that the seed was affected more or less by the treatment.

It will also be seen by comparing tables I and II that oats will stand a higher temperature than wheat.

Thermometers.

It is difficult to secure reliable thermometers, that do not need testing, for less than $1.50. Cheaper thermometers are just as good if they have been properly tested and marked. We have made arrangements with Prof. Woodworth of the Physical Department by which we can secure *properly tested* and *marked thermometers* which we will send by mail to farmers in Mich., at cost price (25c.). We go to this extra trouble hoping that it will be of some help to the farmers.

With a good thermometer there will be no difficulty in following the directions given above; the smut will be destroyed and the seed uninjured.

In conclusion let me say that we shall be pleased to answer any questions regarding smut or do anything else in our power to help rid our crops of this destructive disease which is costing our farmers much more than is generally known even by the farmers themselves.

SUMMARY.

1. The loss to Michigan this year in the oat crop alone caused by smut will exceed $1,000,000.00 and this is a low estimate.
2. The smut of oats and the stinking smut of wheat are parasitic plants.
3. The spores of these smuts attach themselves to the kernels of oats or wheat and are sown with them.
4. The spores germinate at about the same time the seed germinates and in some way enter the young plant and live upon it until, finally, the head of smut appears.
5. Both of these smuts can be entirely prevented at a slight expense by the Jensen or hot water treatment.